Holz als Roh- und Werkstoff (2006) 64: 327–337
DOI 10.1007/s00107-006-0116-x

ORIGINALARBEITEN · ORIGINALS

Birgit A.-L. Östman · Esko Mikkola

European classes for the reaction to fire performance of wood products

Published online: 13 May 2006

Abstract The new classification system for the reaction to fire performance of building products in Europe has been applied to five different product families of wood: Wood-based panels, Structural timber, Glued laminated timber, Solid wood panelling and cladding and Wood flooring as being 'products with known and stable fire performance'. The European classification system includes two sub-systems, one main system for all construction products except floorings and the other for flooring products. Wood properties such as density, thickness, joints and types of end use application including different substrates have been studied thoroughly and are included in the classification. Most wood products fall in classes D-s2, d0 or D_{fl}-s1 (for floorings). Testing has been performed according to EN 13823 (2002) SBI-Single Burning Item test, EN ISO 9239-1 (2002) Radiant panel test, and EN ISO 11925-2 (2002) Small flame test. In all, more than one hundred wood products in different end use applications have been studied. Clear relationships between the main Euroclass fire performance parameters and product parameters (such as density and thickness) have been demonstrated. Tables with reaction to fire classification of different wood products and end use applications have been developed, approved by the European Commission and published in their Official Journal. This procedure is ongoing with further official decisions to be published.

Europäische Klassifizierung des Brandverhaltens von Bauprodukten aus Holz

Zusammenfassung Das neue europäische Klassifizierungssystem zum Brandverhalten von Bauprodukten gilt für die fünf Produktgruppen Holzwerkstoffe, Bauholz, Brettschichtholz, Wand- und Deckenbekleidungen aus Massivholz sowie Holzfußböden, die als "Produkte mit bekanntem und abschätzbarem Brandverhalten" gelten. Das europäische Klassifizierungssystem wird in zwei Kategorien unterteilt: eine Hauptkategorie für alle Bauprodukte mit Ausnahme von Bodenbelägen und eine Kategorie für Bodenbeläge. Holzeigenschaften, wie zum Beispiel Rohdichte, Dicke, Verbindungen und Anwendungsarten einschließlich verschiedener Trägerplatten wurden eingehend untersucht und in die Klassifizierung einbezogen. Die meisten Holzprodukte werden den Klassen D-s2, d0 oder D_{fl}-s1 (Fußböden) zugeordnet. Prüfungen erfolgten nach den Normen EN 13823 (2002) thermische Beanspruchung durch einen einzelnen brennenden Gegenstand, EN ISO 9239-1 (2002) Brandverhalten bei Beanspruchung mit einem Wärmestrahler und EN ISO 11925-2 (2002) Entzündbarkeit von Bauprodukten bei direkter Flammeneinwirkung. Insgesamt wurden über einhundert Holzprodukte in unterschiedlichen praktischen Anwendungsarten untersucht. Eindeutige Zusammenhänge zwischen den Hauptparametern zum Brandverhalten nach der Euroklasse und den Produktparametern (wie zum Beispiel Rohdichte und Dicke) wurden dargestellt. Tabellen mit der Klassifizierung des Brandverhaltens verschiedener Holzprodukte und Endanwendungen wurden erstellt, von der Europäischen Kommission genehmigt und in deren Amtsblatt veröffentlicht. Dieses Verfahren dauert noch an. Die Veröffentlichung weiterer amtlicher Entscheidungen steht noch aus.

B.A.-L. Östman (✉)
SP Trätek / Wood Technology, PO Box 5609, 114 86 Stockholm, Sweden
E-mail: Birgit.Ostman@sp.se

E. Mikkola
VTT, PO Box 1000, 02044 VTT, Finland

Abbreviations

CEN	European Committee for Standardization (fr Comité Européen de Normalisation)
CHF	Critical Heat Flux (parameter determined in the RP test and used for classification)
CWFT	Classification without further testing (procedure within the EC and also a Sub-group under FRG/EGF)
DG	Directorate General (within the EC)
EC	European Commission
EN	European Norm (Standard); prEN is a preliminary standard
EOTA	European Organisation for Technical Approvals
ETA	European Technical Approval

FIGRA FIre Growth RAte (parameter determined in the SBI test and used for classification)
FRG/EGF Fire Regulators Group / European Commission Expert Group on Fire Issues Regarding Construction Products (under SCC); Old (–2004) / New group (2005–)
RP Radiant Panel test for floorings (EN ISO 9239-1 2002)
SBI Single Burning Item test (EN 13823)
SCC Standing Committee on Construction (within the EC)
SMOGRA SMOke Growth RAte (parameter determined in the SBI test and used for classification)
TC Technical Committee (within e.g. CEN)
TSP Total Smoke Production (parameter determined in the SBI test and used for classification)
WG Working Group (under a TC within e.g. CEN)

1 Introduction

1.1 New European classes for the reaction to fire performance of building products

A new classification system for the reaction to fire properties of building construction products has recently been introduced in Europe (COMMISSION DECISION February 2000). It is often called the Euroclass system and consists of two sub systems, one for construction products excluding floorings, i.e. mainly wall and ceiling surface linings, see Table 1, and another similar system for floorings. Both sub systems have classes A to F of which classes A1 and A2 are non combustible products. The new system will replace the present individual European national classification systems, which have formed obstacles to trade (Östman and Nussbaum 1987).

The new European classification system for reaction to fire performance was published in Official Journal in 2000 (COMMISSION DECISION February 2000) and is based on a set of EN standards for different test methods (EN 13823 2002, EN ISO 11925-2 2002, EN ISO 9239-1 2002) and for classification systems (EN 13501-1 2002). Three test methods are used for determining the classes of combustible building products, see Table 2. The methods are illustrated in Fig. 1. For non combustible products additional test methods are also used.

The new European system has to be used for all construction products in order to obtain the CE-mark, which is the official mandatory mark to be used for all construction products on the European market. Different product properties have to be declared and may vary for different products, but the reaction to fire properties is mandatory for all construction products. The normal route is that each manufacturer tests and declares own products individually. Products with known and stable performance may be classified as groups according to an initiative from the EC (CONSTRUCT 01/491 2004). This is a possibility for wood products that have a fairly predictive fire performance. Properties such as density, thickness, joints and type of end use application may influence the classification. If no common rules are available, each producer has to test their products in order to fulfil requirements in product standards and to obtain the CE-mark.

Table 1 Overview of the European reaction to fire classes for building products excl. floorings (COMMISSION DECISION February 2000)
Tabelle 1 Überblick über die Klassifizierung des Brandverhaltens von Bauprodukten ausgenommen Bodenbelägen (COMMISION DECISSION Februar 2000)

Euroclass	Smoke class	Burning droplets class	Requirements according to Non comb	SBI	Small flame	FIGRA W/s	Typical products
A1	–	–	x	–	–	–	Stone, concrete
A2	s1, s2 or s3	d0, d1 or d2	x	x	–	≤ 120	Gypsum boards (thin paper), mineral wool
B	s1, s2 or s3	d0, d1 or d2	–	x	x	≤ 120	Gypsum boards (thick paper), fire retardant wood
C	s1, s2 or s3	d0, d1 or d2	–	x	x	≤ 250	Coverings on gypsum boards
D	s1, s2 or s3	d0, d1 or d2	–	x	x	≤ 750	Wood, wood-based panels
E	–	– or d2	–	–	x	–	Some synthetic polymers
F	–	–	–	–	–	–	No performance determined

SBI = Single Burning Item test (EN 13823), main test for the reaction to fire classes for building products;
FIGRA = FIre Growth RAte, main parameter for the main fire class according to the SBI test

Table 2 European test methods used for determining the reaction to fire classes of combustible building products (COMMISSION DECISION February 2000)
Tabelle 2 Europäische Prüfverfahren zur Klassifizierung des Brandverhaltens brennbarer Bauprodukte (COMMISION DECISSION Februar 2000)

Test method	Construction products excl. floorings	Floorings	Main fire properties measured and used for the classification
Small flame test EN ISO 11925-2 (2002)	x	x	Flame spread within 60 or 20 s
Single Burning Item test, SBI EN 13823 (2002)	x	–	- FIGRA, FIre Growth RAte; - SMOGRA, SMOke Growth RAte; - Flaming droplets or particles
Radiant panel test EN ISO 9239-1 (2002)	–	x	- CHF, Critical Heat Flux; - Smoke production

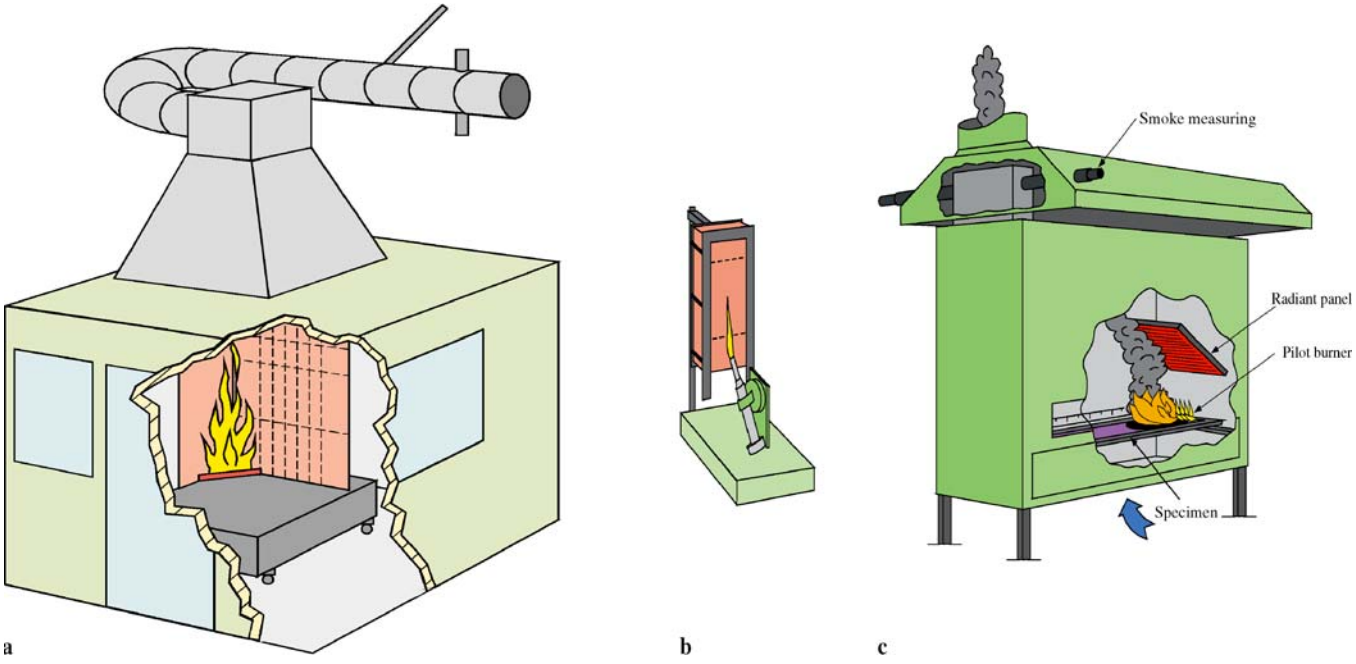

Fig. 1 **a** The SBI test, Single Burning Item test, EN 13823 (2002) (sample size $1.5 \times 1.5\ m^2$); **b** Small flame test, EN ISO 11925-2 (2002) (sample size $0.09 \times 0.25\ m^2$) and **c** Radiant panel test for floorings, EN ISO 9239-1 (2002) (sample size $0.23 \times 1.05\ m^2$)
Abb. 1 **a** SBI-Test. Prüfung zur thermischen Beanspruchung durch einen einzelnen brennenden Gegenstand nach EN 13823 (2002) (Probenabmessung $1{,}5 \times 1{,}5\ m^2$) **b** Prüfung zum Brandverhalten bei Beanspruchung mit einem Wärmestrahler nach EN ISO 11925-2 (2002) (Probenabmessung $0{,}09 \times 0{,}25\ m^2$) und **c** Prüfung zur Entzündbarkeit von Bauprodukten bei direkter Flammeneinwirkung nach EN ISO 9239-1 (2002) (Probenabmessung $0{,}23 \times 1{,}05\ m^2$)

1.2 CWFT – classification without further testing

The procedure for CWFT, Classification without further testing, is described in a document by DG Enterprise (CONSTRUCT 01/491 2004). CWFT corresponds to the definition "Products which have been proven to be stable in a given European class (on the basis of testing to the appropriate EN test method(s)) within the scope of their variability in manufacturing allowed by the product specification (harmonised standard or ETA)". CWFT is a list of generic products, not a list of proprietary products.

CWFT lists are established by Commission Decisions in consultation with the Standing Committee on Construction (SCC). Commission Expert Group on Fire Issues (earlier Fire Regulators Group (FRG)) Regarding Construction Products (EGF), advised by its CWFT Sub-group made up of experts on fire performance of building products and CEN/EOTA TCs (invited for specific cases, as applicants), will consider all requests made and forward recommendations onto the SCC for final opinion. Products claiming CWFT must be clearly above the lower class limits, to provide a safety margin. This should be determined on a statistical basis in relation to the scattering of results. In general terms, each classification parameter (as defined in the relevant classification standard in the EN 13501 series) should be either 20% above the class limit (although some relaxation of this may be possible), or shown by statistical means to have a satisfactory safety level, for a request to be accepted. Due account will be taken of the likely variability in the production process of products.

The SCC will make the final decision based upon the recommendations from the FRG/EGF. All requests and related data will be submitted to the FRG/EGF for discussion. The advice of the FRG/EGF will largely determine whether the request is forwarded to the SCC for opinion.

The CWFT approach has been applied to several wood products. Full reports are available, one for wood products excluding floorings (Östman and Mikkola 2004) and another for floorings (Tsantaridis and Östman 2004).

2 CWFT applications for wood products

2.1 Wood products included

Five different types of wood products are included in the CWFT programme as products with known and stable fire performance:

- Wood-based panels – e.g. particle board
- Structural timber
- Glued laminated timber
- Solid wood panelling and claddings
- Wood floorings

The application of the new European system differs among the various wood products studied as described below. End use application of the products are essential for the reaction to fire classification, e.g. substrates or air gaps behind the wood product, joints and surface profiles. The classification is always related to harmonised product standards in which a CWFT reaction to fire classification table is included. Mounting and fixing conditions have to be specified.

2.2 Harmonised European product standards

The harmonised product specifications for wood products which will include the reaction to fire classifications are:

- EN 13 986 Wood-based panels for use in construction – Characteristics, evaluation of conformity and marking
- EN 14 080 Timber structures – Glued laminated timber – Requirements
- EN 14 081 Timber structures – Strength graded structural timber with rectangular cross section
- EN 14 250 Timber structures – Product requirements for prefabricated structural members assembled with punched metal plate fasteners
- EN 14 342 Wood flooring – Characteristics, evaluation of conformity and marking
- prEN 14 544 Timber structures – Strength graded structural timber with round cross-section – Requirements
- EN 14 915 Solid wood panelling and cladding – Characteristics, evaluation of conformity and marking

All these harmonised product specifications form the basis for the CE-marking of construction products and prescribe which product properties have to be documented.

2.3 End use applications of different wood products

Wood-based panels are mainly used as wall and ceiling linings. End-use conditions without air gaps behind the panel are included. An extension to further end uses is taking place during 2006.

Structural timber and glued laminated timber products are used as parts of wall, roof or floor systems, that may or may not be load bearing. Studs and beams in timber frame systems are usually covered by wood-based or gypsum boards and members of similar systems in solid or glued laminated timber may not be covered. End-use applications also include free standing structural elements, see Fig. 2. A minimum thickness of 22 mm is specified in the product standards for structural timber and 40 mm for glued laminated timber.

Solid wood panellings and claddings are used in interior and exterior applications. It includes vapour barriers with or without an air gap behind the wood product and vertical parts of stairs. End use applications as free standing wood lamellas (called ribbon elements in the official EU documents) are also included. Wood lamellas are defined as rectangular wood pieces, with or without rounded corners, mounted horizontally or vertically on a support frame and surrounded by air on all sides, mainly used close to other building elements, both in interior and exterior applications. Examples of end uses as interior panelling, exterior claddings and free standing wood lamellas are given in Fig. 3.

Wood floorings include both homogenous and multilayer products. The use as steps in stairs with or without an air gap behind are also included, see Fig. 4.

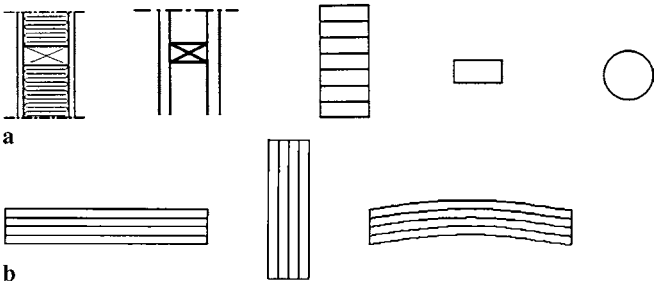

Fig. 2a,b Examples of end uses **a** structural timber as studs (cross-sectional view), beam and free standing elements, **b** glued laminated timber as beams and columns
Abb. 2a,b Anwendungsbeispiele **a** Bauholz als Wandständer (Querschnitt), Balken und freistehende Elemente **b** Brettschichtholz als Balken und Stützen

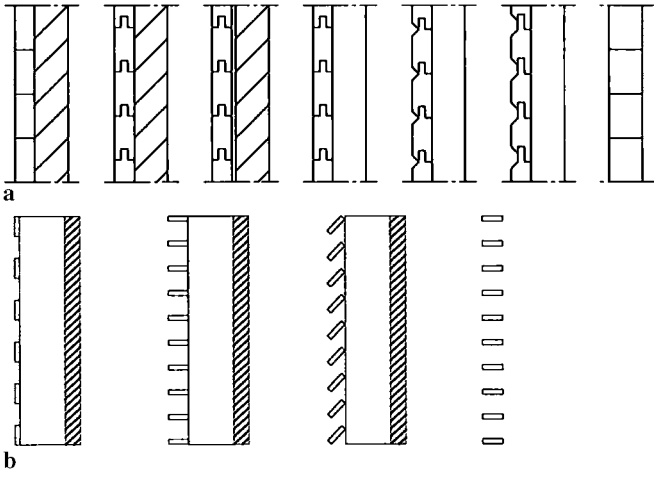

Fig. 3a,b Examples of end uses of solid wood panelling **a** exterior wood claddings with either another material, e.g. insulation, or an air gap behind **b** free standing wood lamellas (ribbon elements)
Abb. 3a,b Anwendungsbeispiele für Wand- und Deckenbekleidungen aus Massivholz **a** Außenbekleidungen aus Holz entweder mit darunter liegendem anderen Material, z.B. Dämmstoff, oder mit einer Hinterlüftung **b** freistehende Holzlamellen

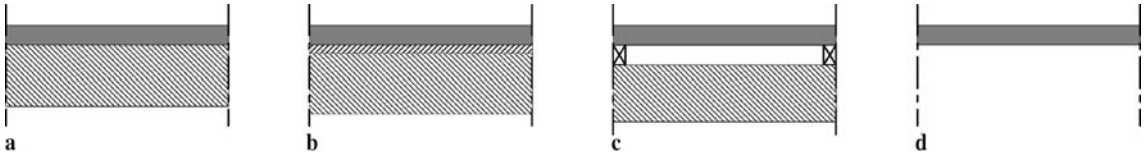

Fig. 4a–d Examples of end uses for wood flooring. **a** Flooring directly on a substrate; **b** with an interlayer between the flooring and the substrate; **c** with a closed air gap in between and **d** with an open air gap without anything underneath (e.g. as in an open staircase)
Abb. 4a–d Anwendungsbeispiele für Holzfußböden **a** Bodenbelag direkt auf Trägerplatte **b** Mit einer Zwischenschicht zwischen Bodenbelag und Trägerplatte **c** Mit einer geschlossenen Luftschicht zwischen Bodenbelag und Trägerplatte und **d** Auf der Unterseite frei belüftet (z.B. frei stehende Treppe)

2.4 Mounting and fixing conditions at fire testing

Wood-based panels may form major parts of the total surfaces of building elements. Thus the whole area for exposure in the SBI apparatus, $1.5 \times 1.5\,m^2$, has been covered with the panel pieces mounted with different specified joints and orientated horizontally or vertically as in the end use application. Different thicknesses and types of panels with insulation or other substrates behind the wood-based panel are included. A schematic sketch of how the sample was mounted in the SBI test is given in Fig. 5.

Structural timber and glued laminated timber products do not generally form a major part of the total surfaces of a room and the number of possible applications is very large. Thus a material testing interpretation has been used. The whole area for the exposure of the test specimen in the SBI apparatus, $1.5 \times 1.5\,m^2$, has been covered with timber pieces mounted edge to edge (butt jointed), without jointing or bonding and orientated horizontally or vertically. This includes the use of timber battens, minimum $40 \times 40\,mm^2$, fixed to the test backing boards at 400–600 mm centres horizontally or vertically (perpendicular to the orientation of the timber pieces). Different thicknesses of timber with and without air gaps or with thermal insulation behind have been investigated to ensure that the fire behaviour is fully independent of the underlying layers.

Solid wood panelling and cladding usually form major parts of the total surfaces of a room, similar to the wood-based panels described above. The whole area for exposure in the SBI apparatus, $1.5 \times 1.5\,m^2$, has been covered with the wood pieces mounted with different specified joints and oriented horizontally or vertically. Different thickness of wood, air gaps, vapour barriers and substrates behind the wood products are included. Examples of interior use of solid wood panelling and free standing wood lamellas elements mounted on a wood batten frame are illustrated in Fig. 3. The free standing wood lamella elements are surrounded by air on all sides.

Wood floorings have been tested in the radiant panel test with and without an air gap underneath. Different thicknesses of flooring, surface coatings, air gaps, interlayers and substrates behind the wood flooring are included, see Fig. 4.

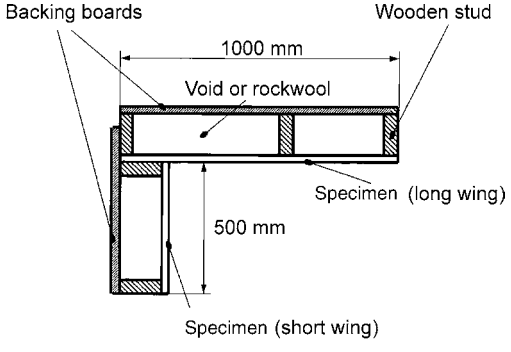

Fig. 5 Schematic view of specimen mounting in the SBI test (as seen from above)
Abb. 5 Anordnung des Prüfkörpers für den SBI-Test (Draufsicht)

3 Test results for different wood products

Wood-based panels without any surface or other treatments have lower FIGRA values at higher densities, see Fig. 6. The FIGRA limit to the lower class E, 750 W/s, is approximately at a density of $350\,kg/m^3$. With a safety margin of 20%, the density limit is about $400\,kg/m^3$. Beyond a density of $500\,kg/m^3$, the FIGRA values are relatively independent of the density. The safety margins for FIGRA to the class D limit are in the order of 20%–60% (Östman and Mikkola 2004). Exceptions are only a few low density products and a rather thin free standing product tested with an air gap behind. Thin 9 mm panels on studs with an open air gap behind did not pass class D. Horizontal or vertical joints and different types of substrates did not influence the fire performance significantly. For the smoke, no similar general trend regarding density has been observed. All products pass the SMOGRA limit with very high margins to class s1, > 60%. However, for the TSP (total smoke production) limit to class s1, some products have safety margins in the order of 30%–60%, while other products do not pass the s1 limit.

Structural timber and glued laminated timber products show also a decrease in FIGRA values with increasing timber density and all values are well below the upper limit, 750 W/s, for class D, see Fig. 7. Both products have been tested with different densities and wood species and with an open air gap behind. The structural timber products were 21–22 mm thick and the glued laminated timber products 40 mm thick and with different glues. The size of the air gap is not important for these quite thick wood products.

Solid wood panelling and cladding products are similarly influenced by density as illustrated in Fig. 8a. For wood densities of at least $390\,kg/m^3$, all FIGRA values are below 600 W/s, i.e. well below the limit to a lower main class, 750 W/s. The in-

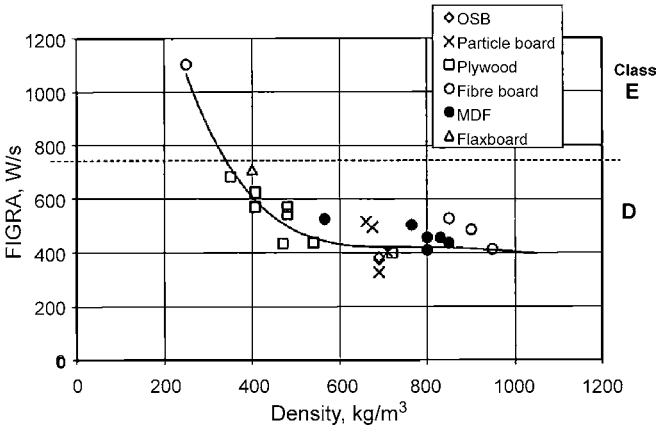

Fig. 6 FIGRA value as a function of density for wood-based panels attached to a calcium silicate substrate. Class D is obtained for all products except for a low density fiberboard
Abb. 6 FIGRA-Wert in Abhängigkeit der Rohdichte von Holzwerkstoffen auf einer Calciumsilikatplatte. Alle Produkte ausgenommen Faserplatten mit geringer Dichte erreichten Klasse D

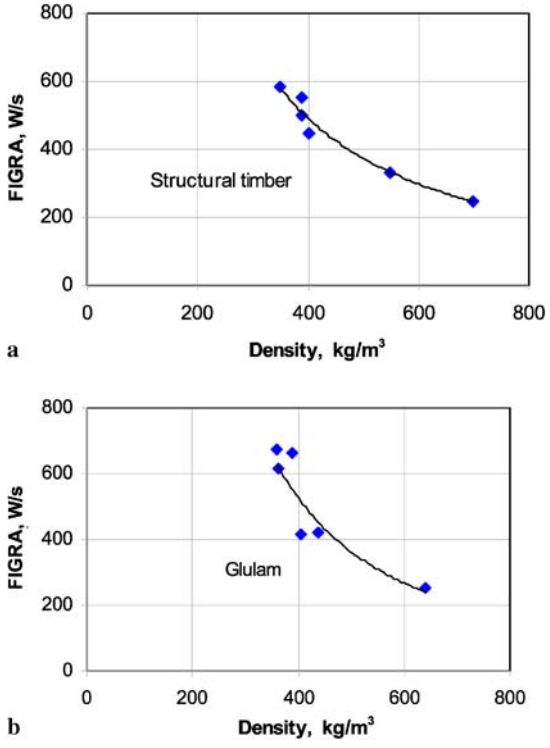

Fig. 7a,b FIGRA value as a function of density for products tested with an open air gap behind **a** 22 mm structural timber and **b** 40 mm glued laminated timber (glulam)
Abb. 7a,b FIGRA-Wert in Abhängigkeit der Rohdichte für auf der Unterseite frei belüftete Proben **a** 22 mm Bauholz und **b** 40 mm Brettschichtholz

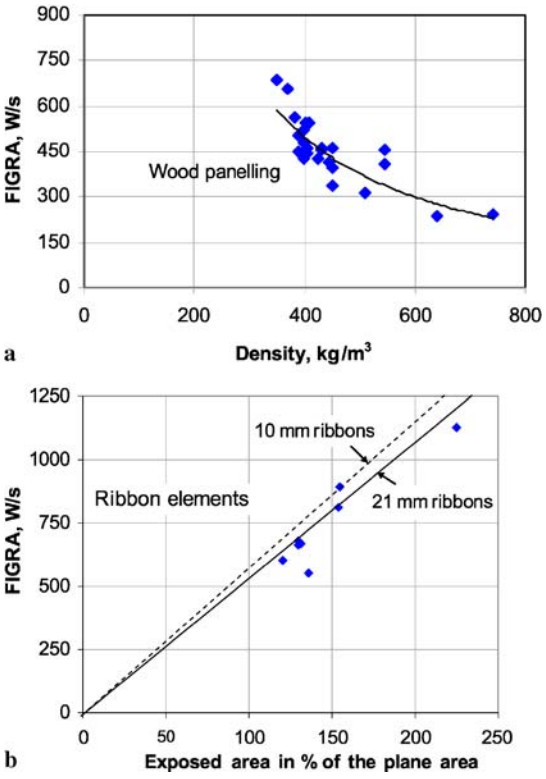

Fig. 8a,b FIGRA value **a** as a function of density for all solid wood panellings and claddings with thickness 9–21 mm and different profile types tested with and without an air gap behind and **b** vs relative exposed area for wood lamellas (ribbons) exposed to fire from all four sides
Abb. 8a,b FIGRA-Wert **a** in Abhängigkeit der Rohdichte von 9–21 mm dicken Wand- und Deckenbekleidungen aus Massivholz mit unterschiedlichen Profilarten mit und ohne Hinterlüftung sowie **b** in Abhängigkeit von der Fläche der Holzlamellen bei vierseitiger Brandbeanspruchung

fluence of thickness and substrates is more indirect and mainly evident from the experience that thinner products burn through and release excessive heat when tested with a void behind. Class D may not be reached (Östman and Mikkola 2004). With a substrate directly behind the wood product, burn through does not occur and class D may thus be reached also for thin products. Panel joints and surface profiled area at the exposed side of the panel not more than 20% of the plane area, or 25% if measured at both exposed and unexposed side of the panel have been shown not to change the fire performance (Östman and Mikkola 2004).

Free standing wood lamella elements with all sides exposed to fire have FIGRA values as a function of the area exposed in

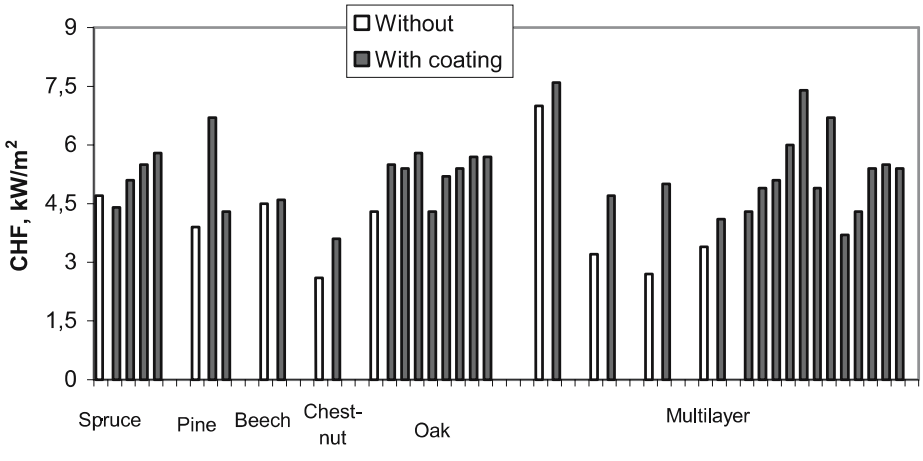

Fig. 9 Critical Heat Flux, CHF, for all wood floorings without and with a surface coat
Abb. 9 Kritischer Wärmestrom (CHF) für alle Holzfußböden mit und ohne Oberflächenbeschichtung

relation to the nominal area in the SBI test method (2.25 m^2), see Fig. 8b.

Wood floorings show a more rapid flame spread in the orientation along the wood grain than transverse grain (Tsantaridis and Östman 2004). The orientation along the grain has therefore been used as the worst case scenario. Coating systems improve or at least maintain the fire performance in the Radiant panel test, i.e. a higher critical heat flux is reached, see Fig. 9. This is a result of a systematic study with well defined uncoated products and coating systems including all mayor systems used by industry, i.e. UV cured acrylic, PU (poly urethane) and oil coating systems used by parquet industry and in addition ordinary wood oil and soap mainly used for solid wood floorings. No clear trend regarding density has been found for wood floorings as for SBI testing of wood products. The lack of trend with density for the wood floorings may be explained by the much lower heat flux in the testing of floorings, allowing gases to be released and influencing the flame spread differently for different wood species, depending e.g. on the wood permeability. A coating system may then decrease the release of gases at low heat flux and thus improve the fire performance. The absence of trend with density is true, both for uncoated and surface coated homogenous wood floorings, see Fig. 10. However, if the test data are analysed per wood species, a certain pattern is obvious. Data for spruce flooring without a surface coating are illustrated in Fig. 10. A trend with density is found mainly for surface coated multilayer wood floorings, see Fig. 11.

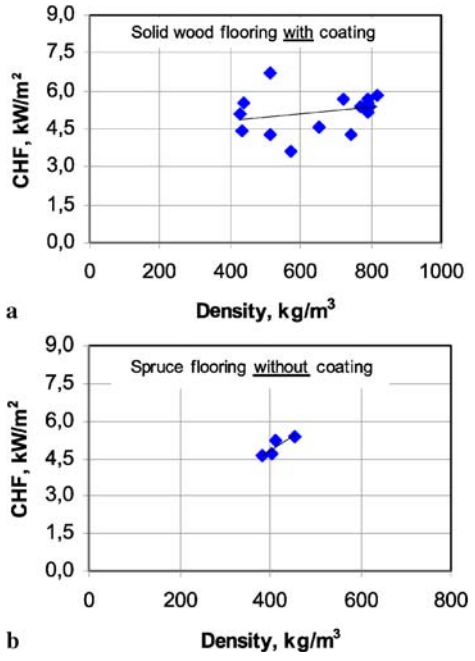

Fig. 10a,b Critical Heat Flux, CHF, as a function of density **a** for solid wood floorings with a surface coat and **b** for solid spruce floorings without a surface coat

Abb. 10a,b Kritischer Wärmestrom (CHF) in Abhängigkeit von der Rohdichte **a** für Massiv-Fußböden mit einer Oberflächenbeschichtung und **b** für Massiv-Fußböden aus Fichtenholz ohne Oberflächenbeschichtung

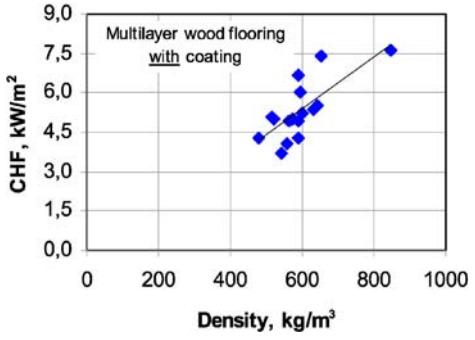

Fig. 11 Critical Heat Flux, CHF, as a function of density for multilayer wood floorings with a surface coat

Abb. 11 Kritischer Wärmestrom (CHF) in Abhängigkeit von der Rohdichte für Mehrschichtparkett mit einer Oberflächenbeschichtung

4 Classification without further testing for wood products

4.1 Wood-based panels

Main class D has been verified for most wood-based panels. Panel density and thickness are decisive for the FIGRA values while panel joints and choice of standard substrates do not influence the class. Only low density products are class E.

Smoke class s2 should be used for all wood-based panels as surface linings in order to achieve a robust classification. Flaming droplets/particles class d0 has been verified for all wood-based panels in class D. The safety margins for these sub-classes are all very high, 20%–90%.

The final classification of wood-based panels published in Official Journal (COMMISSION DECISION January 2003) is given in Table 3. The table has been included in the harmonised product standard for wood-based panels, EN 13986. An extension of the classification for wood-based panels is underway in order to include other panel types and further end use applications, e.g. those with an air gap behind the panel.

4.2 Structural timber

Structural timber with minimum mean density of 350 kg/m^3 and minimum thickness and width of 22 mm can, based on the evidence presented, be classified without further testing as class D-s2, d0.

The final classification of structural timber published in Official Journal (COMMISSION DECISION August 2003) is given in Table 4. It is included in some of the harmonised product standards for structural timber and will be included in those not yet finalised.

4.3 Glued laminated timber

Glued laminated timber with minimum mean density of 380 kg/m^3 and minimum thickness and width of 40 mm can be classified without further testing as class D-s2, d0.

Table 3 Final table in Commission Decision (COMMISSION DECISION January 2003). Classes of reaction to fire performance for wood-based panels[1)]
Tabelle 3 Endgültige Tabelle in der Kommissionsentscheidung (COMMISSION DECISSION Januar 2003). Klassifizierung des Brandverhaltens von Holzwerkstoffen[1)]

Wood-based panel products[2)]	EN product grade reference	Minimum density (kg/m^3)	Minimum thickness (mm)	Class[3)] (excluding floorings)	Class[4)] Floorings
Particleboards	EN 312	600	9	D-s2, d0	D_{FL}-s1
Fibreboards, Hard	EN 622-2	900	6	D-s2, d0	D_{FL}-s1
Fibreboards,	EN 622-3	600	9	D-s2, d0	D_{FL}-s1
Medium		400	9	E, pass	E_{FL}
Fibreboards, Soft	EN 622-4	250	9	E, pass	E_{FL}
Fibreboards, MDF[5)]	EN 622-5	600	9	D-s2, d0	D_{FL}-s1
Cement-bonded particleboard[6)]	EN 634-2	1000	10	B-s1, d0	B_{FL}-s1
OSB board[7)]	EN 300	600	9	D-s2, d2	D_{FL}-s1
Plywood	EN 636	400	9	D-s2, d0	D_{FL}-s1
Solid wood panels	EN 13353	400	12	D-s2, d0	D_{FL}-s1

1) EN 13986
2) Wood-based panels mounted without an air gap directly against class A1 or A2-s1,d0 products with minimum density 10 kg/m^3 or at least class D-s2,d0 products with minimum density 400 kg/m^3
3) Class as provided for in Table 1 of the Annex to Commission Decision 2000/147/EC
4) Class as provided for in Table 2 of the Annex to Commission Decision 2000/147/EC
5) Dry process fibreboard
6) Cement content at least 75% by mass
7) Oriented strand board

Table 4 Final table in Commission Decision (COMMISSION DECISION August 2003). Classes of reaction to fire performance for structural timber[1)]
Tabelle 4 Endgültige Tabelle in der Kommissionsentscheidung (COMMISSION DECISION August 2003). Klassifizierung des Brandverhaltens von Bauholz[1)]

Material	Product detail	Minimum mean density[3)] (kg/m^3)	Minimum overall thickness (mm)	Class[2)]
Structural timber	Visual and machine graded structural timber with rectangular cross-sections shaped by sawing, planing or other methods or with round cross-sections.	350	22	D-s2, d0

1) Applies to all species covered by the product standards
2) Class as provided for in Table 1 of the Annex to Commission Decision 2000/147/EC
3) Conditioned according to EN 13238 (2001)

Table 5 Final table in Commission Decision (COMMISSION DECISION August 2005). Classes of reaction to fire performance for glulam[1)]
Tabelle 5 Endgültige Tabelle in der Kommissionsentscheidung (COMMISSION DECISION August 2005). Klassifizierung des Brandverhaltens von Brettschichtholz[1)]

Material	Product detail	Minimum mean density[3)] (kg/m^3)	Minimum overall thickness (mm)	Class[2)]
Glulam	Glued laminated timber products in accordance with EN 14080.	380	40	D-s2, d0

1) Applies to all species and glues covered by the product standards.
2) Class as provided for in Table 1 of the Annex to Commission Decision 2000/147/EC
3) Conditioned according to EN 13238 (2001).

The final classification of glued laminated timber published in Official Journal (COMMISSION DECISION August 2005) is given in Table 5. The table is included in the harmonised product standard for glued laminated timber EN 14080.

4.4 Solid wood panelling and cladding

Solid wood panelling and cladding with total thickness of at least 9 mm and density of at least 390 kg/m^3 can be classified as class D-s2,d2, and for products with total thickness of at least 12 mm as class D-s2, d0, if mounted with a closed air gap behind or on a non combustible substrate with minimum density 10 kg/m^3 with or without a vapour barrier, e.g. plastic foils, behind the wood panel. A substrate of cellulose insulation of at least class E or an open air gap of maximum 20 mm behind the panel may also be used.

Solid wood panelling and cladding with thickness of at least 18 mm and density of at least 390 kg/m^3 can be classified without further testing as class D-s2, d0 without any limitations in end use conditions.

Wood lamella elements can be classified without further testing as class D-s2, d0, if the maximum exposed area (all sides of rectangular wood pieces and wood support frame) is not more than 110% of the total plane area, see Fig. 12.

A draft proposed Commission Decision for Classification without further testing based on extensive documentation (CWFT doc 062 2004) is given in Table 6.

Table 6 Proposed table for inclusion in Commission Decision (CWFT doc 062 2004). Classes of reaction to fire performance for solid wood panelling and cladding
Tabelle 6 Empfohlene Tabelle zur Aufnahme in die Kommissionsentscheidung (CWFT doc 062 2004). Klassifizierung des Brandverhaltens von Wand- und Deckenbekleidungen aus Massivholz

Product[11)]	Product detail[5)]	Minimum mean density[6)] (kg/m^3)	Minimum thicknesses, total/ minimum[7)] (mm)	End-use condition[4)]	Class[3)]
Panelling and cladding[1)]	Wood pieces with or without tongue and groove and with or without profiled surface	390	9/6	Without air gap or with closed air gap behind	D-s2, d2
-"-	-"-	390	12/8	-"-	D-s2, d0
Panelling and cladding[2)]	-"-	390	9/6	With open air gap $\leq$ 20 mm behind	D-s2, d0
-"-	-"-	390	18/12	Without air gap or with open air gap behind	D-s2, d0
Wood ribbon elements[8)]	Wood pieces mounted on a support frame[9)]	390	18	Surrounded by open air on all sides[10)]	D-s2, d0

1) Mounted mechanically on a wood batten support frame, with the gap closed or filled with a substrate of at least class A2-s1, d0 with minimum density of 10 kg/m^3 or filled with a substrate of cellulose insulation material of at least class E and with or without a vapour barrier behind. The wood product shall be designed for mounting without open joints.
2) Mounted mechanically on a wood batten support frame, with or without an open air gap behind. The wood product shall be designed for mounting without open joints.
3) Class as provided for in Commission Decision 2000/147/EC Annex Table 1. This decision is currently under review in respect of façade applications.
4) An open air gap may include possibility for ventilation behind the product, while a closed air gap will exclude such ventilation. The substrate behind the air gap must be of at least class A2-s1, d0 with a minimum density of 10 kg/m^3. Behind a closed air gap of maximum 20 mm and with vertical wood pieces, the substrate may be of at least class D-s2, d0.
5) Joints include all types of joints, e g butt joints and tongue and groove joints.
6) Conditioned according to EN 13238 (2001).
7) As illustrated in Fig. 12. Profiled area of the exposed side of the panel not more than 20% of the plane area, or 25% if measured at both exposed and unexposed side of the panel. For butt joints, the larger thickness applies at the joint interface.
8) Rectangular wood pieces, with or without rounded corners, mounted horizontally or vertically on a support frame and surrounded by air on all sides, mainly used close to other building elements, both in interior and exterior applications.
9) Maximum exposed area (all sides of rectangular wood pieces and wood support frame) not more than 110% of the total plane area, see Fig. 13.
10) Other building elements closer than 100 mm from the wood ribbon element (excluding its support frame) must be of at least class A2-s1, d0, at distances 100–300 mm of at least class B-s1, d0 and at distances more than 300 mm of at least class D-s2, d0.
11) Applies also to stairs.

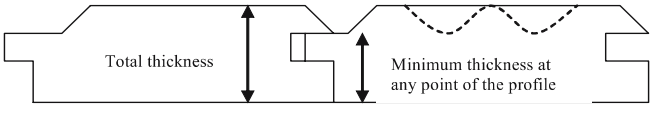

Fig. 12 Profiles for solid wood panelling and cladding (specification to Table 6)
Abb. 12 Profile für Wand- und Deckenbekleidungen aus Massivholz

4.5 Wood flooring

The following general conclusions are reached for wood floorings (see Sect. 3):

- Along wood grain is the worst case orientation
- Surface coatings generally improve the fire performance (probably due to a decreased release of wood pyrolysis gases during initial fire exposure)
- Most wood floorings fulfil at least class D_{fl}-s1, some also class C_{fl}-s1

More specific conclusions are included in a draft proposed Commission Decision for Classification without further testing ba-

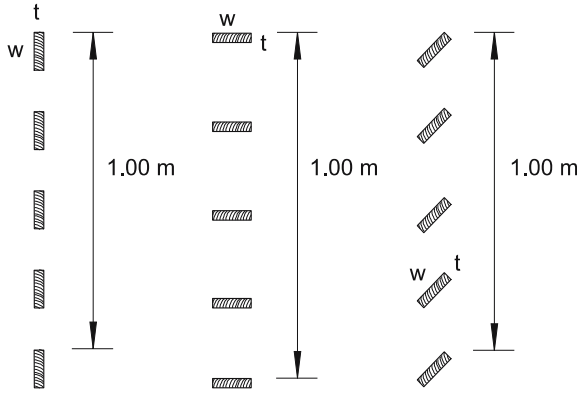

Fig. 13 Maximum exposed area of wood ribbon element: 2n (t+w) + a $\leq$ 1.10 (specification to Table 6)
Abb. 13 Maximale brandbeanspruchte Fläche von Holzlamellen: 2n (t+w) + a $\leq$ 1,10
n is number of wood pieces per meter
t is thickness of each wood piece, in meter
w is width of each wood piece, in meter
a is exposed area of wood support frame (if any), in m^2,
per m^2 of wood ribbon element

Table 7 Proposed table for inclusion in Commission Decision (CWFT doc 061 2004). Classes of reaction to fire performance for wood flooring
Tabelle 7 Empfohlene Tabelle zur Aufnahme in die Kommissionsentscheidung (CWFT doc 061 2004). Klassifizierung des Brandverhaltens von Holzfußböden

Product[1,7)]	Product detail[4)]	Minimum mean density[5)] (kg/m^3)	Minimum overall thickness (mm)	End use condition	Class[3)] for floorings
Wood flooring and parquet	Solid flooring of oak or beech with surface coating	Beech: 680 Oak: 650	8	Glued to substrate[6)]	C_{fl}-s1
-"-	Solid flooring of oak, beech or spruce and with surface coating	Beech: 680 Oak: 650 Spruce: 450	20	With or without air gap underneath	C_{fl}-s1
-"-	Solid wood flooring with surface coating and not specified above	390	8	Without air gap underneath	D_{fl}-s1
-"-	-"-	390	20	With or without air gap underneath	D_{fl}-s1
Wood parquet	Multilayer parquet with a top layer of oak of at least 5 mm thickness and with surface coating	650 (top layer)	10	Glued to substrate[6)]	C_{fl}-s1
-"-	-"-	650 (top layer)	14[2)]	With or without air gap underneath	C_{fl}-s1
-"-	Multilayer parquet with surface coating and not specified above	500	8	Glued to substrate	D_{fl}-s1
-"-	-"-	500	10	Without air gap underneath	D_{fl}-s1
-"-	-"-	500	14[2)]	With or without air gap underneath	D_{fl}-s1
Veneered floor covering	Veneered floor covering with surface coating	800	6[2)]	Without air gap underneath	D_{fl}-s1

1) Mounted in accordance with EN ISO 9239-1 (2002), on a substrate of at least Class D-s2,d0 and with minimum density of 400 kg/m^3 or with an air gap underneath.
2) An interlayer of at least Class E and with maximum thickness 3 mm may be included in applications without an air gap, for parquet products with 14 mm thickness or more and for veneered floor coverings.
3) Class as provided for in Commission Decision 2000/147/EC Annex Table 2.
4) Type and quantity of surface coatings included are acrylic, polyurethane or soap, 50–100 g/m^2, and oil, 20–60 g/m^2.
5) Conditioned according to EN 13238 (2001) (50% RH 23 °C)
6) Substrate at least Class A2-s1, d0.
7) Applies also to steps of stairs.

sed on extensive documentation (CWFT doc 061 2004), see Table 7.

5 Conclusions

The results clearly demonstrate the stable reaction to fire performance of wood based products. Classes D-s2, d0, D_{fl}-s1 and C_{fl}-s1 have been verified with the required safety limit of 20%. The main parameters influencing the reaction to fire characteristics of all wood products are product thickness, density and end use conditions such as substrates or air gaps behind the product.

The work has already resulted in Commission decisions published in the Official Journal of the Commission for wood-based panels and structural timber products. Remaining results are in progress of being finally approved and published. The classes will also be included in the harmonised product specifications as soon as they become available from the product standard committees and used for CE-marking.

In addition to the CWFT decisions, this new knowledge can be utilized in predicting classifications for wood products not covered by the EC decisions or for new products.

Wood products and end use applications not included in the CWFT classification tables need to be tested and classified in the ordinary way. Better classification may then be reached, since no safety margins have to be fulfilled.

Fire retardant treated wood products must always be tested and classified separately, since the treatments may influence their reaction to fire performance.

Acknowledgement The work has been initiated by standard bodies within CEN TC 112, TC 124 and TC 175. It has been lead and sponsored by European industrial federations via CEI-Bois, mainly EPF European Panel Federation, FEIC European Federation of the Plywood Industry, FEROPA European Federation of the Fibreboard Industry, EOS European Organisation of the Sawmill Industry, the European Glued Laminated Industries and FEP European Federation of the Parquet Industry. The contribution of products for tests and discussions with several European companies are kindly acknowledged.

References

CONSTRUCT 01/491 rev 3 (2004) Classification of products of known and stable performance – Procedural aspects
COMMISSION DECISION of 8 February 2000 implementing Council Directive 89/106/EEC as regards the classification of the reac-

tion to fire performance of construction products. Off J Eur Commun 23.2.2000
COMMISSION DECISION of 17 January 2003 establishing the classes of reaction-to-fire performance of certain construction products. Off J Eur Commun 18.1.2003
COMMISSION DECISION of 7 August 2003 amending Decision 2003/43/EC establishing the classes of reaction-to-fire performance of certain construction products. Off J Eur Union 8.8.2003
COMMISSION DECISION of 9 August 2005 establishing the classes of reaction-to-fire performance of certain construction products. Off J Eur Union 11.8.2005
CWFT doc 062 (2004) case report for Solid wood panelling and cladding, rev 6. October 2004
CWFT doc 061 (2004) case report for Wood floorings, rev 8. December 2004
EN 13823 (2002) Reaction to fire tests for building products – Building products excluding floorings – exposed to the thermal attack by a single burning item. SBI test
EN ISO 11925-2 (2002) Reaction to fire tests for building products – Ignitability of building products subjected to direct impingement of flame – Part 2: Single-flame source test
EN ISO 9239-1 (2002) Reaction to fire tests for floor coverings – Part 1: Determination of the burning behaviour using a radiant heat source
EN 13501-1 (2002) Fire classification of construction products and building elements – Part 1: Classification using test data from reaction to fire tests
EN 13238 (2001) Reaction to fire tests for building products – Conditioning procedures and general rules for selection of substrates
Östman B, Nussbaum R (1987) National standard fire tests in small-scale compared with the full-scale ISO room test. Trätek Report I 8702017
Östman B, Mikkola E (2004) European classes for the reaction to fire of wood products (excluding floorings). Trätek Report I 0411025
Tsantaridis L, Östman B (2004) European classes for the reaction to fire of wood floorings. Trätek Report I 0411026

Test reports (main examples):

- SBI test results of wood products, VTT Building Technology Internal Report, January 1998
- Study of fire classification of wood based panels, VTT Building Technical Research Report No RTE3366/02, 2002
- Fire tests of Sitka spruce according to EN 13823:2002 (SBI) test procedure, VTT Research Reports No RTE 136/03 and RTE 432/03, 2003
- Reaction to fire test EN 13823, CTBA Test Reports No 03/PC/PHY/107-1–4, 2003
- Fire tests of wood panelling and cladding according to EN 13823:2002 (SBI) test procedure, VTT Research Reports No RTE 2236 /03 and RTE 4212 /03, 2003
- Fire tests of wooden grating structures according to EN 13823:2002 (SBI) test procedure, VTT Research Reports No RTE 3259 /03 and RTE 4148 /03, 2003
- Prüfbericht Nr. PB III/B-03-226 vom 06/08/2003 1. Ausfertigung, MFPA Leipzig GmbH, 2003
- Fire tests according to EN 13823, 2002 (SBI method), Report P300091, 2003-03-18, SP Fire Technology, 2003
- Fire testing of homogenous wood floorings according to EN ISO 9239-1, Trätek Test Reports A12413/2003-09-04 and A 12465/2004-02-24, 2004
- Fire testing of multilayer wood floorings according to EN ISO 9239-1, Trätek Test Reports A12414/2003-09-04 and A 12466/2004-02-24, 2004